EFFECT OF ROW SPACING AND NITROGEN FFERTILIZATION ON YIELD AND QUALITY OF TWO SUUGARCANE VARIETIES

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ABSTRACT

The present work was conducted at Shandaweel Agricultural Research Station, Sohag Governorate during 2009/2010 (plant cane) and 2010/2011 (first ratoon) to investigate the effect of three row spacing (80, 100 and 120 cm), three nitrogen levels (170, 200 and 230 kg N/fed in plant cane and 185, 215 and 245 kg N/fed in the 1st ratoon) on yield and quality of two sugarcane varieties *viz.* G.99-160 and G.T.54-9 (the commercial variety) in a split-split plot design with three replications.

The results showed that planting sugarcane varieties in rows spaced at 80-cm apart attained a significant increases in cane stalk height, number of millable canes, cane yield/fed, brix, sucrose, sugar recovery percentages and sugar yield/fed compared with those planted at 100 and 120 cm. Significant increase in stalk diameter was recorded at 120 cm row spacing.

The results indicated that the two sugarcane varieties differed significantly in cane stalk height, stalk diameter, number of millable canes, cane and sugar yields, whether they were grown as plant cane or 1st ratoon crop, as well as brix, sucrose percentages in the 1st ratoon. Insignificant variance was detected between the tested varieties in sugar recovery %, in the plant and 1st ratoon crops.

Raising N fertilization level from 170 to 200 kg N/fed for the plant cane and from 185 to 215 kg N/fed for the 1st ratoon crop resulted in a significant increase in cane stalk height, stalk diameter, number of millable canes, cane and sugar yields /fed.

Under conditions of the present work, growing G.T.54-9 and/or G.99-160 sugarcane varieties in rows of 80-cm apart and fertilized with 200 and 215 kg N/fed for the plant cane or 1st ratoon, respectively, can be recommended to get the maximum cane and sugar yields/fed.

Key words: Row spacing, nitrogen fertilization, yield and quality of two sugarcane varieties.

INTRODUCTION

It is known that the differences among genotypes and varieties are attributed to the variation in foliage size (leaf area), number of stomata on both sides of leaves, thickness of cuticle (wax layer), soil and meteorological factors prevailed. In Egypt, many studies were carried out to evaluate sugarcane varieties for productivity and quality traits. Significant variations among varieties were reported by **Shafshak *et al*, 2001; El-Geddawy *et al*, 2002** and **Mohamed and Ahmed 2002**. Also, in India, **Gowda *et al* (2001)** evaluated the performance of two sugarcane cultivars, *i.e.* Co-7704 and CoC-671 and noticed that the former recorded higher average cane (129.9 tons/ha) and sugar (19.0 tons/ha) yields than the latter (126.20 and 18.20 tons/ha, respectively). **Tiwari *et al* (2004)** noticed that cv CoS 91269 followed by cvs CoSe 93232 and CoSe 95427 performed better in terms of yield, whereas cvs CoSe 92234 and CoSe 92423 were better in terms of juice quality. **Sinha *et al* (2005)** found that CoP 9702, BO 128 and BO 91 genotypes produced significantly higher cane yield of 55.20, 51.96 and 49.51 tons/ha and sugar yield of 6.27, 6.05 and 5.63 tons/ha, respectively than cvs CoP 9502 and CoP 9206. In Egypt, **Azzazy *et al* (2005)** found that G.T.54-9, Phli.8013, G.95-21, G.99-165, G.98-28 and G.95-19 sugarcane varieties differed significantly in their stalk height and diameter, sucrose % and sugar recovery % as well as cane and sugar yields. **El-Shafai and Ismail (2006)** showed that sugarcane commercial cv. G.T.54-9 was superior in stalk height, number of millable cane, cane and sugar yields/fed compared with Phil.8013, G.95-19, G.95-21 varieties, while thicker stalks, higher sucrose and sugar recovery percentages were given by Phil.8013. **Ismail *et al*. (2008)** found that sugarcane varieties differed significantly in all the studied traits in plant and first ratoon crops except purity%, cane and sugar yields in the plant cane. The commercial cv. G.T.54-9 showed superiority in stalk length, purity%, sugar recovery% and sugar yields/fed. Higher number of millable canes and cane yield were given by G.95-21 variety, whereas thicker stalks were recorded by phil.8013 variety.

Row spacing has a direct effect on plant population. It plays a distinct role in the amount of solar radiation and hence, crop canopy development, which in turn affects photosynthesis and ultimately the dry matter produced by plant. **Avtar (2000)** planted sugarcane in single rows (75 or 90 cm) or double rows (120:60, 60:30 or 120:30 cm). He found that single row spacing of 75 cm produced the highest mean yield of 55.5 tons, which was insignificantly different from double row spacing of 60:30 (52.0 tons) and 120:60 (51.0 tons). **El-Geddawy, *et al*. (2002-a)** found that narrow row spacing (100cm) produced higher number of millable canes, cane and sugar yields compared to 120 and/or 140-cm row spacing. F. 153 cultivar produced the highest number of millable cane and cane yield, while G. T. 54-9 had the highest sugar recover% and sugar yield. Their results showed that the wider row spacing (140 cm) significantly recorded higher values for stalk height, higher number of internodes/stalk and thicker stalks, compared with those of narrower spacing of 100 cm. Sugarcane G.T. 54-9 cultivar significantly surpassed the other cultivars in terms of stalk height, stalk diameter and number of internodes/plant. **El-Geddawy, *et al*. (2002-b)** they added that the widest row spacing gave the highest sucrose, and sugar recovery percentage. They found that varieties differed significantly in juice quality traits where F. 153 cultivar was superior to the other cultivars in sucrose and sugar recovery **(El-Geddawy, *et al*. (2002-c)**. **Raskar and Bhoi (2003)** studied the effect of intra-row spacing of 30, 60 or 90 cm. They found that cane girth and number of millable canes were significantly higher with a 90-cm intra-row spacing compared with 30 or 60-cm intra-row spacing. Millable cane height was insignificantly affected by spacing. **Rizk *et al*. (2004-a)** found that sucrose was insignificantly affected by the studied row distances (100, 120 and 140 cm). Likewise, **Rizk *et al*. (2004-b)** showed that number of internodes/stalk was insignificantly influenced by the same row distances. However, the widest row distance significantly gave the thickest stalks. **El-Shafai and Ismail (2006)** indicated that planting sugarcane in rows spaced at 80-cm apart attained a significant increase in cane stalk height, number of millable canes, cane and sugar yields/fed compared with 100 and 120 cm, while sucrose, sugar recovery percentages were insignificantly affected by row spacing.

Regarding nitrogen fertilization effect, **Shafshak *et al* (2001)** found that increasing N-level from 150 to 190 kg N/fed significantly increased stalk height and stalk diameter. No significant difference was detected in stalk height between 190 and 230 kg N/fed. Nitrogen level had insignificant effect on sucrose or reducing sugar content. **Mahender *et al* (2002)** fertilized sugarcane with 75, 100, 125, and 150 % of the recommended dose (150 kg N/ha). They found that cane yield and yield attributes were the highest with the application of 125 and 150% of the recommended N dose. **Ahmed (2003)** found that application of 240 kg N/fed gave the highest values of the number of millable canes/m^2, millable cane length, cane and sugar yields/fed. **Srinivas *et al* (2003)** fertilized sugarcane with nitrogen (0, 250, and 375 kg N/ha). They reported that the increase in N rate resulted in the increase of the number of shoots and millable canes, cane yield, and sugar yield. **Tiwari *et al* (2004)** tested the effect of three N levels given to sugarcane (100, 150 and 200 kg N/ha). They noticed that increasing N level increased number of tillers, millable canes, yield components and cane yield. Sucrose % was deteriorated when N level was further than 150 kg/ha. **Azzazy *et al* (2005)** supplied sugarcane with three N levels (180, 210 and 240 kg N/fed). They found that increasing N level up to 240 kg N/fed resulted in a significant increase in stalk height, stalk diameter and cane yield of the plant cane but decreased sucrose and sugar recovery percentages. Sugar yield was insignificantly affected by N levels. **Ismail *et al*. (2008)** found increasing N levels up to 232.5 kg N/fed significantly increased number of millable canes, cane and sugar yields/fed in the plant and first ratoon crops. Stalk length and quality traits were insignificantly affected by N levels. **Mokadem *et al*. (2008)** reveled that increasing N levels attained a positive and significant effects on stalk height, millable canes/fed, cane yield/fed, sugar yield/fed and sugar recovery%. Fertilizing sugar cane with 240 kg N/fed recorded the highest values of the studied traits.

The objective of this work was to find out the best combination of the studied factors to attain the maximum cane and sugar yields under conditions of Sohag Governorate.

MATERIALS AND METHODS

The present investigation was carried out at Shandaweel Agricultural Research Station, Sohag Governorate during 2009/2010 (spring plant cane) and 2009/2011 (first ratoon crop) growing seasons. Treatments included three row spacing (80, 100 and 120 cm), two sugarcane varieties namely G.99-160 and G.T.54-9 (commercial check variety) and three N levels (170, 200, and 230 kg N/fed in the plant cane and 185, 215 and 245 kg N/fed in the first ratoon). Nitrogen fertilizer (Urea, 46.5% N) was added in two equal doses. In the plant cane, the 1^{st} N dose was applied 50 days after planting, preceded with hoeing. In the 1^{st} ratoon, the 1^{st} N-dose was added one month after harvesting of the plant cane and furrowing (ditching between rows of sugarcane) and earthing-up. The 2^{nd} N-dose was added one month after the 1^{st} one, for both cane crops. A split-split plot design with three replications was used, where row spacing were allocated in the main plots, the sub plots were assigned for the two sugarcane varieties, while the three N levels were distributed in the sub-sub plots. The sub-sub plot area was 60 m^2, including 15, 12 and 10 rows in the case of spacing 80, 100 and 120 cm spacing, respectively and 5 m in length). Plant cane was planted in the 3^{rd} week of March. Both plant and 1^{st}

first ratoon canes were harvested at age of 12 months. Soil chemical and mechanical analyses of the experimental site showed that the upper 30-cm of the soil was clay loam (29.4% sand, 10.4% silt and 59.6% clay) and contained 34.0, 11.7 and 210 ppm available N, P, K, respectively, with pH of 7.4. Recommended P and K fertilizers were added during seed bed preparation at rates of 30 kg P_2O_5 (as superphosphate, 15.5%) and 72 kg K_2O (as potassium sulphate 48% K_2O)/fed, respectively. The other agricultural practices were done as recommended by Sugar Crops Research Institute. The following data were recorded:

Yield and its components:

I. At harvest, ten plants were randomly taken to determine stalk height (cm) and stalk diameter (cm). Plants of the guarded rows were harvested, cleaned, topped and the following parameters were recorded: number of millable canes/fed, cane yield (ton/fed) and sugar yield (ton/fed) was estimated according to the following equation:

Raw sugar production = cane yield (tons/fed) x sugar recovery %.

II. Quality traits:

A sample of 20 millable cane stalks was collected immediately after harvesting, cleaned and crushed to determine quality traits:

* Brix percentage (total soluble solids, TSS %) in juice was determined using Brix Hydrometer standardized at 20 C^o.
* Sucrose/100 cm^3 juice was determined using Sacharemeter according to **A.O.A.C. (1995)**.
* Sugar recovery percentage was calculated according to the equation outlined by **Yadav and Sharama (1980)**:

Sugar recovery % = [sucrose % - 0.4(brix % - sucrose %)] x 0.73.

The collected data were statistically analyzed according to **Snedecor and Cochran (1981)**. Treatment means were compared using LSD at 5% level.

RESULTS AND DISCUSSION:

Stalk height:

Data in Table 1 show that increasing row spacing from 80 to 100 and 120 cm led to a significant decrease in cane stalk height in the plant and 1st ratoon crops. This result could be due to the competition among cane plants for light in the dense planting, *i.e.* narrower row spacing. **Chang (1974)** reported that the proportion of invisible solar radiation is so much increased than the visible solar radiation due to dense sowing. The former has an elongation effect and hence accounts for the increase observed in stalk height when sugarcane was planted in close spaced rows. The same finding was reported by **Mohamed and Ismail (2002)** who found that cane stalk height increased with decreasing row spacing from 150 to 90 cm.

The two sugarcane varieties differed significantly in stalk height in the cane crop. Sugarcane G.99-160 variety had higher stalks than those of G.T.54-9. The difference between the tested cvs may be due to their gene make-up. This result is in agreement with that found by **Azzazy *et al*. (2005)** and **El-Shafai and Ismail (2006)**. However, the difference between them in this trait was insignificant in the 1st ratoon.

Data in Table 1 clear that increasing the applied N levels from 170 to 200 kg N/fed, in the plant cane crop led to a significant increase in stalk height. Similar result was observed in the 1st ratoon crop when N fertilization was raised from 185 to 215 kg N/fed. The increase in stalk height may be attributed to the role of nitrogen as an essential element in building-up plant organs and enhancing their growth. These results are in agreement with those reported by **Ahmed (2003); Azzazy *et al*. (2005)** and **Mokadem *et al*. (2008)**. In addition, a slight reduction in stalk height was detected in both plant and 1st ratoon crops by increasing the applied N fertilizer to the highest level, which may indicate that the 2nd N-level was enough to get the highest value of this trait. Meantime, there was insignificant difference in stalk height of the 1st ratoon of sugarcane received the middle (215 kg N/fed) or the highest (245 kg N/fed N-level).

Except for the 2nd order interaction among the three studied factors in the 1st ratoon, stalk height was significantly influenced by the other possible interactions between levels of the studied factors in both seasons.

Table 1: Stalk height cm of two sugarcane varieties as affected by row spacing, nitrogen fertilizer levels and their interactions in 2009/2010 and 2010/2011 seasons.

Row spacing (cm) (A)	Sugar cane varieties (B)	Stalk height (cm)							
		The plant cane				The 1st ratoon			
		Nitrogen kg/fed (C)			Mean	Nitrogen kg/fed (C)			Mean
		170	200	230		185	215	245	
80	G. 99-160	308.00	316.33	317.67	**314.00**	314.00	320.33	323.00	**319.11**
	G.T.54-9	303.00	310.33	314.67	**309.33**	308.00	315.68	318.33	**314.00**
Mean		**305.50**	**313.33**	**316.17**	**311.67**	**311.00**	**318.00**	**320.67**	**316.56**
100	G. 99-160	305.67	314.00	311.67	**310.44**	311.67	315.67	314.00	**313.78**
	G.T.54-9	297.67	304.67	306.67	**303.00**	304.00	309.33	314.67	**309.33**
Mean		**301.67**	**309.33**	**309.17**	**306.72**	**307.83**	**312.50**	**314.33**	**311.56**
120	G. 99-160	308.33	300.00	289.67	**299.33**	312.33	308.33	297.67	**306.11**
	G.T.54-9	307.67	309.33	303.67	**306.89**	313.67	313.33	307.33	**311.44**
Mean		**308.00**	**304.67**	**296.67**	**303.11**	**313.00**	**310.83**	**302.50**	**308.78**
Overall mean of varieties	G. 99-160	307.33	310.11	306.33	**307.93**	312.67	314.78	311.56	**313.00**
	G.T.54-9	302.78	308.11	308.33	**306.41**	308.56	312.78	313.44	**311.59**
Mean of nitrogen		**305.06**	**309.11**	**307.33**		**310.61**	**313.78**	**312.50**	

LSD at 0.5 level for:			
Row spacing	(A)	1.59	1.04
Varieties	(B)	1.29	NS
Nitrogen levels	(C)	1.73	1.57
(A) x (B)		2.24	2.91
(A) x (C)		3.00	2.71
(B) x (C)		2.45	2.22
(A) x (B) x (C)		4.24	NS

2. Stalk diameter:

Data in Table 2 show a significant and gradual increase in cane stalk diameter associated with widening spacing between rows from 80 to 100 and 120 cm in the plant cane and the 1st ratoon. This result may be attributed to lower competition for nutrients, water and solar radiation among cane plants grown in wider rows, which reflected in better growth conditions, compared with those grown in narrower ones. This result is in accordance with those reported by **El-Geddawy *et al*. (2002-a)** and **Rizk (2004-b)**.

Sugarcane G.99-160 variety had thicker stalks than G.T.54-9 (Table 2). The difference between the two varieties in this trait was significant in both seasons, which could be due to their genetic structure. Those results are in agreement with those found by **Ahmed (2003)** and **Azzazy *et al*. (2005)**.

The results clear that increasing the applied N levels up to the 2nd N-level (200 and 215 kg N/fed, in the plant cane or 1st ratoon crop, respectively) resulted in a significant increase in stalk diameter. This result may be attributed to the role of N element in building-up plant organs and enhancing plant growth. These results are in agreement with those reported by **Ahmed (2003); Azzazy *et al*. (2005)** and **Mokadem *et al*. (2008)**. Moreover, a slight reduction in stalk diameter was recorded in both plant and 1st ratoon crops accompanying the increase in N fertilization to the highest level, which may indicate that the addition of N fertilizer should be stopped at the 2nd N-level to obtain the thickest stalks.

As for the significant interaction effects, stalk diameter was significantly affected by the interactions between row spacing and cane varieties in plant cane. The other interactions had significant effects on stalk diameter of the 1st ratoon.

Table 2: Stalk diameter (cm) of two sugarcane varieties as affected by row spacing, nitrogen fertilizer levels and their interactions in 2009/2010 and 2010/2011 seasons.

Row spacing (cm) (A)	Sugar cane varieties (B)	Stalk diameter (cm)							
		The plant cane				The 1st ratoon			
		Nitrogen kg/fed (C)			Mean	Nitrogen kg/fed (C)			Mean
		170	200	230		185	215	245	
80	G. 99-160	2.59	2.65	2.58	**2.61**	2.55	2.63	2.54	**2.57**
	G.T.54-9	2.55	2.60	2.58	**2.58**	2.51	2.54	2.52	**2.52**
Mean		**2.57**	**2.63**	**2.58**	**2.59**	**2.53**	**2.58**	**2.53**	**2.55**
100	G. 99-160	2.62	2.69	2.67	**2.66**	2.61	2.66	2.61	**2.63**
	G.T.54-9	2.60	2.65	2.61	**2.62**	2.54	2.65	2.58	**2.59**
Mean		**2.61**	**2.67**	**2.64**	**2.64**	**2.57**	**2.65**	**2.60**	**2.61**
120	G. 99-160	2.71	2.75	2.75	**2.74**	2.65	2.69	2.66	**2.67**
	G.T.54-9	2.65	2.70	2.66	**2.67**	2.60	2.68	2.63	**2.64**
Mean		**2.68**	**2.73**	**2.70**	**2.70**	**2.63**	**2.69**	**2.64**	**2.65**
Overall mean of varieties	G. 99-160	2.64	2.70	2.67	**2.67**	2.60	2.66	2.60	**2.62**
	G.T.54-9	2.60	2.65	2.61	**2.62**	2.55	2.62	2.58	**2.58**
Mean of nitrogen		**2.62**	**2.67**	**2.64**		**2.58**	**2.64**	**2.59**	

LSD at 0.5 level for:			
Row spacing	(A)	0.01	0.01
Varieties	(B)	0.01	0.01
Nitrogen levels	(C)	0.02	0.02
(A) x (B)		0.01	NS
(A) x (C)		NS	0.03
(B) x (C)		N S	0.02
(A) x (B) x (C)		N S	0.04

3. Number of millable canes/fed:

Data in Table 3 cleared that increasing distance between rows from 80 up to 120 cm resulted in a significant reduction in the number of millable canes/fed in the plant cane and the 1st ratoon. This result could be due that widening distance between rows to 120 cm decreased the density of planting material, *i.e.* cane cuttings. This result is in agreement with those mentioned by **El-Geddawy *et al*. (2002-a)** and **Raskar and Bhoi (2003)**.

Sugarcane G.T.54-9 cv. showed a significant superiority in the tillering ability amounted to 1.33 and 1.70 thousand millable canes/fed over that produced by G.99-160, in the plant and its 1st ratoon, respectively (Table 3). Differences among cane varieties in this trait were also found by **Ahmed (2003); Azzazy *et al*. (2005)** and **Ismail *et al*. (2008)**.

Significant increases of 1.08 and 0.94 thousand millable canes/fed were obtained by supplying sugarcane grown as a plant cane with 200 kg N/fed or as 1st ratoon with 215 kg N/fed, compared with that recorded by applying 170 or 185 kg N/fed, respectively. Thereafter, a slight and insignificant reduction in this trait was recorded by raising N-level to the highest one in both plant and 1st ratoon crops. Meantime, it was noticed that the difference in number of millable canes/fed gained by adding 185 and/or 245 kg N/fed was insignificant in the 1st ratoon crop. These results showed that the 2nd N-level was enough to obtain the maximum record of this trait in the 1st and 2nd seasons. These results coincided with those given by **Ismail *et al*. (2008)** and **Mokadem *et al*. (2008)**.

All interactions had insignificant influence on this trait in both seasons.

Table 3: Number of millable canes (1000/fed) of two sugarcane varieties as affected by row spacing, nitrogen fertilizer levels and their interactions in 2009/2010 and 2010/2011 seasons.

Row spacing (cm) (A)	Sugar cane varieties (B)	Number of millable canes (1000/fed)							
		The plant cane				The 1st ratoon			
		Nitrogen kg/fed (C)			Mean	Nitrogen kg/fed (C)			Mean
		170	200	230		185	215	245	
80	G. 99-160	53.04	54.17	54.59	**53.93**	53.66	54.47	54.95	**54.36**
	G.T.54-9	54.70	55.00	54.53	**54.75**	55.62	56.20	55.73	**55.85**
Mean		**53.87**	**54.59**	**54.56**	**54.34**	**54.64**	**55.34**	**55.34**	**55.11**
100	G. 99-160	49.61	51.28	49.58	**50.15**	50.37	51.87	49.90	**50.71**
	G.T.54-9	50.44	51.57	51.47	**51.16**	51.77	52.14	52.22	**52.04**
Mean		**50.02**	**51.43**	**50.53**	**50.66**	**51.07**	**52.01**	**51.06**	**51.38**
120	G. 99-160	46.37	47.69	47.89	**47.32**	47.04	48.51	48.59	**48.04**
	G.T.54-9	49.17	50.09	49.24	**49.50**	49.91	50.87	50.15	**50.31**
Mean		**47.77**	**48.89**	**48.57**	**48.41**	**48.48**	**49.69**	**49.37**	**49.18**
Overall mean of varieties	G. 99-160	49.67	51.05	50.68	**50.47**	50.36	51.62	51.15	**51.04**
	G.T.54-9	51.44	52.22	51.75	**51.80**	52.44	53.07	52.70	**52.74**
Mean of nitrogen		**50.55**	**51.63**	**51.22**		**51.40**	**52.34**	**51.92**	

LSD at 0.5 level for:			
Row spacing	(A)	0.46	o.23
Varieties	(B)	0.56	0.52
Nitrogen levels	(C)	0.54	0.62
(A) x (B)		NS	NS
(A) x (C)		NS	NS
(B) x (C)		NS	NS
(A) x (B) x (C)		NS	NS

4. Cane yield:

Data in Table 4 clear that cane yield was significantly and negatively influenced by increasing row spacing, where the wider the row spacing, the lower the cane yield and vice versa. This result was true in both of the plant and 1st ratoon crops. This result can be attributed to lower values of stalk height (Table 1) and number of millable canes/fed (Table 3) at the widest row spacing (120 cm). Planting sugarcane in rows spaced at 80-cm apart produced 2.29 and 4.58 tons/fed of cane higher than that grown at 100 and 120-cm rows, respectively, in the plant cane, and 2.26 and 4.92 tons/fed in the 1st ratoon. These results are in agreement with those reported by **El-Geddawy *et al*. (2002-a)** and **El-Shafai and Ismail (2006)**.

Sugarcane G.T.54-9 variety exhibited the superiority in cane yield recording significant increases amounted to 1.54 and 0.88 tons/fed higher than those produced by G.99-160 variety, in the plant and 1st ratoon canes, respectively. These results could be attributed to higher values of stalk height and number of millable canes/fed (Table 3). These results are in agreement with those reported by **Ahmed (2003); Azzazy *et al*. (2005)** and **Ismail *et al*. (2008)**.

Cane yield responded significantly and positively to the applied N doses. Increasing N-dose from 170 to 200 kg N/fed increased cane yield of the plant cane by 1.28 ton/fed. Likewise, raising N-level from 185 to 215 kg N/fed increased cane yield of the 1st ratoon by 1.34 ton/fed. These results are probably due to the increase in cane stalk height, diameter and number of millable canes/fed (Tables 1, 2 and 3, respectively). These results are in agreement with those reported by **Ismail *et al*. (2008)** and **Mokadem *et al*. (2008)**. However, increasing N fertilization level to 230 and 245 kg N/fed given to the plant cane and its 1st ratoon, respectively, resulted in a significant reduction of 1.00 and 1.13 tons in cane yield/fed. This result may be due to the fact that higher application of N element direct cane plants towards the vegetative growth late in the season producing heavy tops, indicating that the application of N-fertilizer must not exceed the middle N-level for both plant and 1st ratoon crops.

Cane yield was significantly affected by the interaction between row spacing and N levels in the 1st ratoon. Insignificant variance in cane yield was found in cane plants grown in rows of 80-cm apart and fertilized with 215 and 245 kg N/fed. However, the difference in cane yield between these two levels of N reached the level of significance when sugarcane was grown in rows of 100 and 120 cm.

Table 4: Cane yield (ton/fed) of two sugarcane varieties as affected by row spacing, nitrogen fertilizer levels and their interactions in 2009/2010 and 2010/2011 seasons.

Row spacing (cm) (A)	Sugar cane varieties (B)	Cane yield (ton/fed)							
		The plant cane				The 1st ratoon			
		Nitrogen kg/fed (C)			Mean	Nitrogen kg/fed (C)			Mean
		170	200	230		185	215	245	
80	G. 99-160	55.24	56.00	56.26	**55.83**	56.45	57.53	57.50	**57.19**
	G.T.54-9	57.10	58.58	57.22	**57.64**	57.85	59.20	58.56	**58.53**
Mean		**56.17**	**57.29**	**56.74**	**56.73**	**57.15**	**58.36**	**58.03**	**57.85**
100	G. 99-160	53.24	54.67	53.59	**53.84**	55.11	56.46	54.15	**55.24**
	G.T.54-9	54.17	56.19	54.77	**55.04**	55.38	56.82	55.58	**55.93**
Mean		**53.71**	**55.43**	**54.18**	**54.44**	**55.25**	**56.64**	**54.87**	**55.59**
120	G. 99-160	51.91	51.20	50.92	**51.35**	53.45	52.29	52.18	**52.64**
	G.T.54-9	51.84	54.53	52.47	**52.95**	51.38	55.36	52.92	**53.22**
Mean		**51.87**	**52.87**	**51.69**	**52.15**	**52.42**	**53.83**	**52.55**	**52.93**
Overall mean of varieties	G. 99-160	53.47	53.96	53.59	**53.67**	55.00	55.43	54.61	**55.01**
	G.T.54-9	54.37	56.43	54.82	**55.21**	54.87	57.13	55.69	**55.89**
Mean of nitrogen		**53.92**	**55.20**	**54.20**		**54.94**	**56.28**	**55.15**	

LSD at 0.5 level for:			
Row spacing	(A)	1.01	0.37
Varieties	(B)	0.42	0.33
Nitrogen levels	(C)	0.49	0.36
(A) x (B)		NS	NS
(A) x (C)		NS	0.62
(B) x (C)		0.70	0.51
(A) x (B) x (C)		1.21	0.88

Cane yield was significantly affected by the interaction between cane varieties and N levels in both seasons. In the plant cane, the difference in cane yield of G.T.54-9 variety given the lowest and the highest N level was insignificant, while the difference in cane yield gained by applying the middle N level and any of the other two N levels was significant. Similar result was detected with G.99-160 grown as 1st ratoon, where the difference in cane yield between the lowest and middle N level in cane yield was insignificant, while the difference between the two N levels and the highest one was significant. The 2nd order interaction among the three studied factors had a significant influence on cane yield/fed in both seasons. In the plant cane, the difference in cane yield produced by the two cane varieties was insignificant when they were given 170 kg N/fed and grown in rows of 100 and/or 120-cm apart. However, the difference in cane yield between the two varieties grown in rows of 80 cm and fertilized with the same N level was significant. Similar results were obtained in the 1st ratoon crop.

5. Brix percentage:

Data in Table 5 show that increasing distance between rows from 80 up to 120 cm resulted in a significant reduction in the brix percentage in the plant cane. This result is in agreement with those mentioned by **El-Geddawy *et al*. (2002-c)** and **Sundara (2003)**.

Sugarcane G.T.54-9 cv. showed a significant superiority in the brix percentage over that recorded by G.99-160, in the 1st ratoon. Differences among cane varieties in this trait were also found by **Ahmed (2003)**.

Data in Table 5 clear that increasing the applied N from the lowest levels (170 and 185 kg N/fed, in the plant and 1st ratoon cane crop, respectively) to the highest level (230 and 245 kg N/fed, in the plant and 1st ratoon cane crop, respectively) led to a gradual and significant increase in brix percentage. Similar results were observed by **Mokadem *et al.* (2008)**. Moreover, the difference between the middle and the highest N levels in their effects on this trait was insignificant, in both cane crops.

None of the interactions among the studied factors had a significant effect on this trait in both seasons.

Table 5: Brix percentage of two sugarcane varieties as affected by row spacing, nitrogen fertilizer levels and their interactions in 2009/2010 and 2010/2011 seasons.

Row spacing (cm) (A)	Sugar cane varieties (B)	Brix percentage							
		The plant cane				The 1st ratoon			
		Nitrogen kg/fed (C)			Mean	Nitrogen kg/fed (C)			Mean
		170	200	230		185	215	245	
80	G. 99-160	19.30	20.31	21.30	**20.30**	19.40	20.60	21.47	**20.49**
	G.T.54-9	19.88	21.14	20.85	**20.62**	20.04	21.32	21.27	**20.88**
Mean		**19.59**	**20.73**	**21.08**	**20.46**	**19.72**	**20.96**	**21.37**	**20.68**
100	G. 99-160	19.33	20.28	20.25	**19.95**	19.41	20.51	20.51	**20.14**
	G.T.54-9	19.65	20.15	20.41	**20.07**	19.94	20.54	20.73	**20.40**
Mean		**19.49**	**20.22**	**20.33**	**20.01**	**19.68**	**20.52**	**20.62**	**20.27**
120	G. 99-160	19.75	20.12	20.42	**20.10**	19.99	20.31	20.64	**20.31**
	G.T.54-9	19.44	20.20	19.58	**19.74**	19.62	21.33	20.34	**20.43**
Mean		**19.60**	**20.16**	**20.00**	**19.92**	**19.81**	**20.82**	**20.49**	**20.37**
Overall mean of varieties	G. 99-160	19.46	20.24	20.66	**20.12**	19.60	20.47	20.87	**20.32**
	G.T.54-9	19.66	20.50	20.28	**20.14**	19.87	21.06	20.78	**20.57**
Mean of nitrogen		**19.56**	**20.37**	**20.47**		**19.73**	**20.77**	**20.83**	

LSD at 0.5 level for:			
Row spacing	(A)	0.16	0.31
Varieties	(B)	NS	0.25
Nitrogen levels	(C)	0.43	0.43
(A) x (B)		NS	NS
(A) x (C)		NS	NS
(B) x (C)		NS	NS
(A) x (B) x (C)		NS	NS

6. Sucrose percentage:

Data in Table 6 show that increasing row spacing from 80 to 100 and 120 cm led to a significant decrease in sucrose percentage in the plant and 1st ratoon crops. The same finding was reported by **El-Geddawy, *et al*. (2002-c)**.

The two sugarcane varieties differed significantly in sucrose % in the 1st ratoon crop. Sugarcane G.T.54-9 variety had higher sucrose % than that of G.99-160. The difference between the tested cvs may be due to their gene make-up. This result is in agreement with that found by **Azzazy *et al*. (2005); El-Shafai and Ismail (2006)** and **Mokadem *et al*. (2008)**. However, the difference between them in sucrose % was insignificant in the plant cane crop.

Data in Table 6 clear that increasing the applied N levels from 170 to 230 kg N/fed, in the plant cane crop led to a significant increase in sucrose percentage. Similar result was observed when the 1st ratoon crop was N fertilization was raised from 185 to 245 kg N/fed. These results are in agreement with those reported by **Mokadem *et al*. (2008).** Meantime, there was insignificant difference in sucrose % in the plant cane and the 1st ratoon when they were fertilized with middle and/or the highest N level.

None of the possible interactions had a significant influence on sucrose percentage of the plant cane. Except for the interaction between row spacing and N levels and the 2nd order interaction among the studied factors, sucrose % of the 1st ratoon cane crop was insignificantly affected by the other interactions. As for the interaction between row spacing and N levels, the results showed that the difference in sucrose % in cane stalks of the 1st ratoon grown in rows of 80 and 100-cm apart and fertilized with middle and highest N levels was insignificant. However, the difference between the two N levels in their effect on this trait reached the level of significance at 120-cm.

Table 6: Sucrose percentage of two sugarcane varieties as affected by row spacing, nitrogen fertilizer levels and their interactions in 2009/2010 and 2010/2011 seasons.

Row spacing (cm) (A)	Sugar cane varieties (B)	Sucrose percentage							
		The plant cane				The 1st ratoon			
		Nitrogen kg/fed (C)			Mean	Nitrogen kg/fed (C)			Mean
		170	200	230		185	215	245	
80	G. 99-160	17.13	18.18	18.30	**17.87**	17.23	18.40	18.52	**18.05**
	G.T.54-9	17.57	18.15	18.22	**17.98**	17.68	18.30	18.83	**18.27**
Mean		**17.35**	**18.17**	**18.26**	**17.93**	**17.46**	**18.36**	**18.67**	**18.16**
100	G. 99-160	17.10	17.93	17.77	**17.60**	17.37	18.26	17.93	**17.85**
	G.T.54-9	17.42	17.76	18.00	**17.73**	17.66	18.16	18.55	**18.12**
Mean		**17.26**	**17.84**	**17.88**	**17.66**	**17.52**	**18.21**	**18.24**	**17.99**
120	G. 99-160	17.58	17.65	17.85	**17.69**	17.66	17.74	18.03	**17.81**
	G.T.54-9	17.30	17.86	17.53	**17.56**	17.68	18.57	17.77	**18.01**
Mean		**17.44**	**17.76**	**17.69**	**17.63**	**17.67**	**18.15**	**17.90**	**17.91**
Overall mean of varieties	G. 99-160	17.27	17.92	17.97	**17.72**	17.42	18.13	18.16	**17.90**
	G.T.54-9	17.43	17.92	17.92	**17.76**	17.67	18.34	18.39	**18.13**
Mean of nitrogen		**17.35**	**17.92**	**17.94**		**17.55**	**18.24**	**18.27**	

LSD at 0.5 level for:			
Row spacing	(A)	0.11	0.07
Varieties	(B)	NS	0.23
Nitrogen levels	(C)	0.26	0.25
(A) x (B)		NS	NS
(A) x (C)		NS	0.43
(B) x (C)		NS	NS
(A) x (B) x (C)		NS	0.69

7. Sugar recovery percentage:

Data in Table 7 point out that sugar recovery% was insignificantly influenced by row spacing in the plant cane and the 1st ratoon. This result is in agreement with those mentioned by **El-Geddawy *et al*. (2002-c)** and **Sundara (2003)**.

Data in Table 7 show that the studied varieties did not differ significantly in sugar recovery% in the plant cane and the 1st ratoon crops. **Ahmed (2003) and Azzazy *et al*. (2005)** came up with the same result.

The results cleared that increasing the applied N levels from 170 to 200 kg N/fed, in the plant cane crop led to a significant increase in sugar recovery%. Similar result was observed when the 1st ratoon crop as a result of raising N fertilization level was raised from 185 to 215 kg N/fed. These results are in agreement with those reported by **Ahmed (2003); Azzazy *et al*. (2005)** and **Mokadem *et al*. (2008)**. Meantime, it was found that the difference between the middle and highest N level in their effect on this trait was insignificant, in both cane crops.

In respect to the significant interaction effects, sugar recovery% was significantly affected by the interaction between row spacing and N levels in the plant cane and the 1st ratoon. The 2nd order interaction among the three studied factors had a significant influence on sugar recovery% in both seasons. Insignificant variance in sugar recovery% was found in cane plant grown in rows of 100-cm or 120-cm apart and fertilized with the lowest and middle N-level. However, the difference in sugar recovery% between these two N levels reached the level of significance when sugarcane was grown in rows of 80 cm. However, the difference in this trait between these two N levels was insignificant in the 1st ratoon grown in rows of 120-cm apart, while the difference was between the two N levels was significant in canes grown in rows of 80 and 100 cm.

Table 7: Sugar recovery percentage of two sugarcane varieties as affected by row spacing, nitrogen fertilizer levels and their interactions in 2009/2010 and 2010/2011 seasons.

Row spacing (cm) (A)	Sugar cane varieties (B)	Sugar recovery percentage							
		The plant cane				The 1st ratoon			
		Nitrogen kg/fed (C)			Mean	Nitrogen kg/fed (C)			Mean
		170	200	230		185	215	245	
80	G. 99-160	11.47	12.23	11.76	**11.82**	11.54	12.34	11.94	**11.94**
	G.T.54-9	11.68	11.66	11.94	**11.76**	11.72	11.77	12.49	**11.99**
Mean		**11.58**	**11.95**	**11.85**	**11.79**	**11.63**	**12.05**	**12.22**	**11.97**
100	G. 99-160	11.40	11.90	11.71	**11.67**	11.72	12.21	11.77	**11.90**
	G.T.54-9	11.62	11.77	11.92	**11.77**	11.78	12.05	12.45	**12.10**
Mean		**11.51**	**11.84**	**11.82**	**11.72**	**11.75**	**12.13**	**12.11**	**11.97**
120	G. 99-160	11.79	11.64	11.72	**11.71**	11.73	11.64	11.81	**11.73**
	G.T.54-9	11.60	12.30	11.83	**11.91**	12.00	12.09	11.49	**11.86**
Mean		**11.69**	**11.97**	**11.77**	**11.81**	**11.87**	**11.87**	**11.65**	**11.80**
Overall mean of varieties	G. 99-160	11.55	11.93	11.73	**11.74**	11.66	12.06	11.84	**11.86**
	G.T.54-9	11.63	11.91	11.90	**11.81**	11.84	11.97	12.15	**11.98**
Mean of nitrogen		**11.59**	**11.92**	**11.81**		**11.75**	**12.02**	**11.99**	

LSD at 0.5 level for:			
Row spacing	(A)	NS	NS
Varieties	(B)	NS	NS
Nitrogen levels	(C)	0.13	0.21
(A) x (B)		NS	NS
(A) x (C)		0.31	0.31
(B) x (C)		NS	NS
(A) x (B) x (C)		0.31	0.44

8. Sugar yield/fed:

Data in Table 8 reveal that sugar yield/fed was significantly and negatively affected by row spacing in the plant cane and the 1st ratoon, where the wider the row spacing, the lower the sugar yield and vice versa. Planting sugarcane in rows spaced at 80-cm apart produced 0.26 and 0.64 tons/fed of sugar higher than that grown at 100 and 120-cm rows, respectively, in the plant cane, and 0.30 and 0.57 tons/fed in the 1st ratoon. These results are in agreement with those reported by **El-Shafai and Ismail (2006)**.

Sugarcane G.T.54-9 variety exhibited the superiority in sugar yield recording significant increases amounted to 0.25 and 0.35 tons/fed higher than those produced by G.99-160 variety, in the plant and 1st ratoon canes, respectively. These results are in agreement with those reported by **El-Shafai and Ismail (2006)** and **Ismail *et al*. (2008)**.

Sugar yield responded significantly and positively to the applied N doses. Increasing N-dose from 170 to 200 kg N/fed increased sugar yield of the plant cane by 0.30 ton/fed. Likewise, raising N-level from 185 to 215 kg N/fed increased cane yield of the 1st ratoon by 0.34 ton/fed. These results are in agreement with those reported by **Ismail *et al*. (2008)** and **Mokadem *et al*. (2008)**. However, increasing N fertilization level to 230 and 245 kg N/fed given to the plant cane and its 1st ratoon, respectively, resulted in a significant reduction of 0.12 and 0.l9 ton of sugar yield/fed. This result is probably due to the same tendency recorded for cane yield/fed as affected by the applied N levels (Table 4) and sugar recovery % (Table 7), where these are the two factors participate in the amount of extractible sugar/fed.

Sugar yield was significantly affected by the interaction between row spacing and N levels in the plant cane and the 1st ratoon. Insignificant variance in sugar yield was found in plant canes grown in rows of 80-cm or 100-cm apart and fertilized with 200 and 230 kg N/fed. However, the difference in sugar yield between these two N levels reached the level of significance when sugarcane was grown in rows of 120 cm. In the 1st ratoon, the difference between the middle and highest N levels in their effect on sugar yield was significant under 100 and 120 cm spacing, without significant variance between the two N levels when canes were grown in rows of 80-cm apart.

The 2nd order interaction among the three studied factors had a significant influence on sugar yield/fed in both seasons. In the plant cane, the difference in sugar yield produced by the two cane varieties was insignificant when they were given 170 kg N/fed and grown in rows of 100 and/or 120-cm apart. However, the difference in cane yield between the two varieties grown in rows of 80 cm and fertilized with the same N level was significant. In the 1st ratoon, the difference in sugar yield obtained from the two varieties was insignificant in case of growing them in rows of 100-cm apart and fertilizing them with 170 kg N/fed. However, the difference in cane yield between the two varieties grown in rows of 80 and/or 120 cm and fertilized with the same N level was significant.

CONCLUSION

Under conditions of the present work, growing G.T.54-9 and/or G.99-160 sugarcane varieties in rows of 80-cm apart and fertilized with 200 and 215 kg N/fed for the plant cane or 1st ratoon, respectively, can be recommended to get the maximum cane and sugar yields/fed.

Table 8: Sugar yield (ton/fed) of two sugarcane varieties as affected by row spacing, nitrogen fertilizer levels and their interactions in 2009/2010 and 2010/2011 seasons.

Row spacing (cm) (A)	Sugar cane varieties (B)	Sugar yield (ton/fed)							
		The plant cane				The 1st ratoon			
		Nitrogen kg/fed (C)			Mean	Nitrogen kg/fed (C)			Mean
		170	200	230		185	215	245	
80	G. 99-160	6.37	6.91	6.72	**6.67**	6.47	7.04	6.76	**6.76**
	G.T.54-9	6.69	6.89	7.14	**6.91**	6.76	6.90	6.99	**6.88**
Mean		**6.53**	**6.90**	**6.93**	**6.79**	**6.62**	**6.97**	**6.88**	**6.82**
100	G. 99-160	6.24	6.68	6.31	**6.41**	6.29	6.72	6.34	**6.45**
	G.T.54-9	6.38	6.77	6.82	**6.66**	6.44	6.69	6.63	**6.58**
Mean		**6.31**	**6.72**	**6.56**	**6.53**	**6.36**	**6.70**	**6.49**	**6.52**
120	G. 99-160	6.09	5.96	6.02	**6.02**	6.30	6.09	6.12	**6.17**
	G.T.54-9	6.22	6.59	6.03	**6.28**	5.96	6.81	6.26	**6.34**
Mean		**6.16**	**6.28**	**6.02**	**6.15**	**6.13**	**6.45**	**6.19**	**6.25**
Overall mean of varieties	G. 99-160	6.23	6,52	6.35	**6.37**	6.35	6.62	6.41	**6.46**
	G.T.54-9	6.43	6.75	6.66	**6.62**	6.39	6.80	6.63	**6.60**
Mean of nitrogen		**6.33**	**6.63**	**6.51**		**6.37**	**6.71**	**6.52**	

LSD at 0.5 level for:			
Row spacing	(A)	0.22	0.03
Varieties	(B)	0.09	0.07
Nitrogen levels	(C)	0.10	0.09
(A) x (B)		NS	NS
(A) x (C)		0.18	0.16
(B) x (C)		NS	NS
(A) x (B) x (C)		0.26	0.22

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تأثير مسافة التخطيط والتسميد النيتروجينى على حاصل وجودة صنفين من قصب السكر

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** قسم المحاصيل- كلية الزراعة- جامعة الازهر- اسيوط

أُقيمت تجربتان حقليتان فى محطة البحوث الزراعية بشندويل بمحافظة سوهاج خلال موسمى الزراعة ٢٠٠٩/٢٠١٠ (قصب الغرس) و ٢٠١٠/٢٠١١ (قصب خلفة اولى) وذلك لدراسة تأثير المسافة بين الخطوط ومستويات التسميد النيتروجينى على حاصل وجودة صنفين من القصب هما الصنف التجارى جيزة ٥٤-٩ والصنف المبشر جيزة ٩٩-١٦٠ فى تصميم القطع المنشقة مرتين فى ثلاث مكررات.

أوضحت النتائج أن زراعة قصب السكر فى خطوط على مسافة ٨٠ سم حققت زيادة معنوية فى صفات طول وقطر العود وعدد العيدان القابلة للعصر، وحاصل العيدان والسكر/فدان والنسبة المئوية لكلٍ من البركس والسكروز وناتج السكر مقارنة بالزراعة فى خطوط على مسافة ١٠٠ أو ١٢٠ سم – فى حين حققت الزراعة على ١٢٠سم زيادة معنوية فى قطر العود فقط .

دلت النتائج على وجود فروقاً معنوية بين صنفى القصب فى طول وقطر العود وعدد العيدان القابلة للعصر، وحاصل العيدان والسكر/فدان سواء فى القصب الغرس أو الخلفة الأولى - بينما إختلف الصنفان فى النسبة المئوية للبركس والسكروز معنوياً فى القصب الخلفة – فى حين لم يتباين الصنفان معنوياً فى النسبة المئوية لناتج السكر فى القصب الغرس أو الخلفة الأولى .

بينت النتائج أن زيادة مستوى السماد اللنيتروجينى للقصب الغرس من ١٧٠ إلى ٢٠٠ أو زيادته من ١٨٥ إلى ٢١٥ للخلفه الاولى حققت زيادة معنوية لصفات طول وقطر العود وعدد العيدان القابلة للعصر، وحاصل العيدان والسكر/فدان .

تحت ظروف هذا البحث، يمكن التوصية بزراعة أيٍ من صنفى القصب جيزة-تايوان ٥٤-٩ و/أو جيزة ٩٩-١٦٠ فى خطوط بينها مسافة ٨٠ سم مسمداً بإضافة ٢٠٠ كجم نيتروجين/فدان للغرس و٢١٥ كجم نيتروجين/فدان للخلفة الاولى للحصول على أعلى حاصل عيدان وسكر/فدان.